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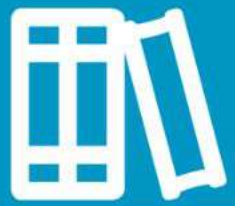

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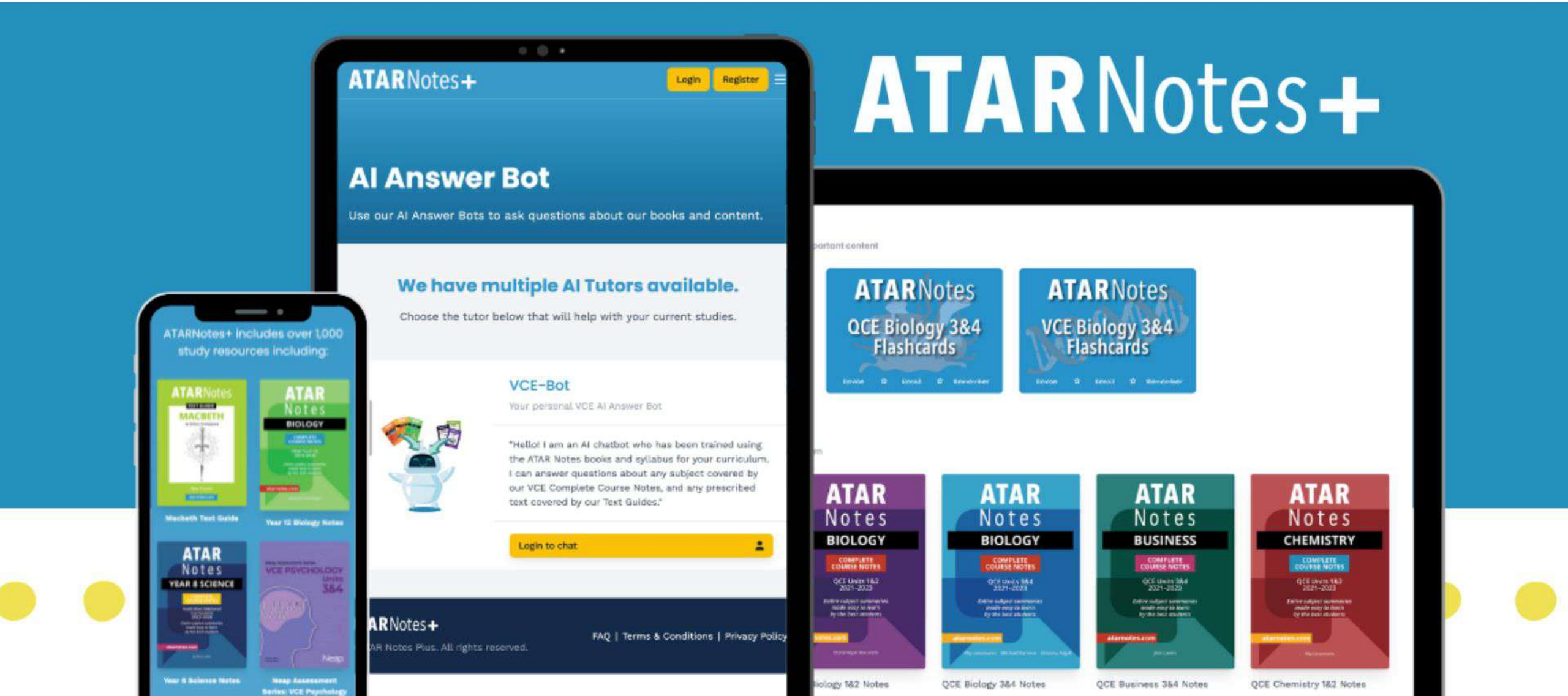

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Year 10 Science

ATARNotes January Lecture Series

Presented by:
Michelle W

Year 10 Science Lecture

Topics to be covered

- **Biological sciences (content blocks 1 & 2)**

1) Transmission of heritable characteristics from one generation to the next involves DNA and genes
2) The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence

- **Chemical sciences (content block 2)**

1) The atomic structure and properties of elements are used to organise them in the Periodic Table
2) Different types of chemical reactions are used to produce a range of products and can occur at different rates

Announcements

- This lecture will run in two chunks, totalling 1.5 hours
- You'll be able to ask questions online via the chat
- You can download the pdf version of the slides now!

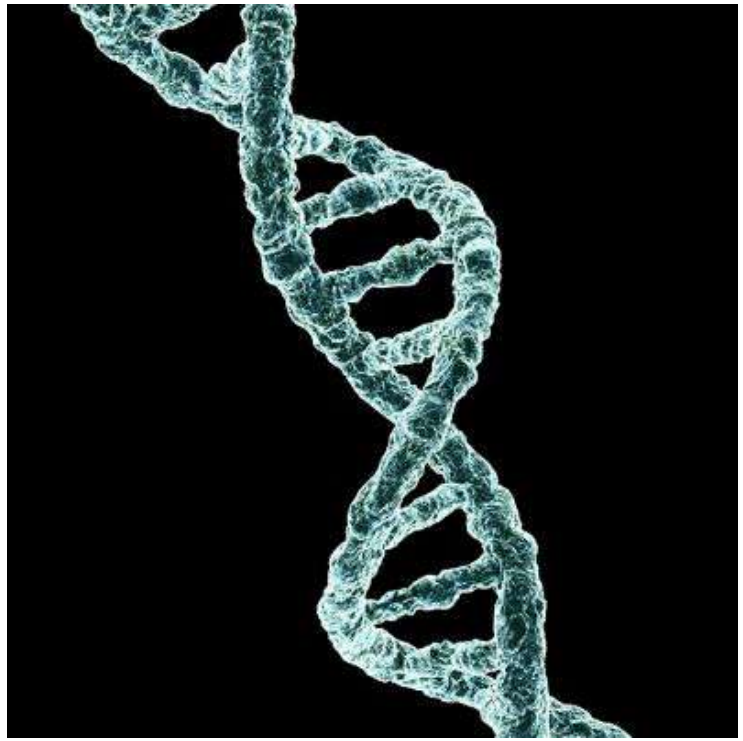
Biological Sciences - DNA & Genetics

Transmission of heritable characteristics from one generation to the next involves DNA and genes

DNA & Genetics

- DNA as the blueprint for controlling the characteristics of organisms

  DNA = deoxyribonucleic acid



DNA carries the genetic material of an organism within each cell and is hereditary

DNA is a double-stranded helix, the strands run antiparallel to each other

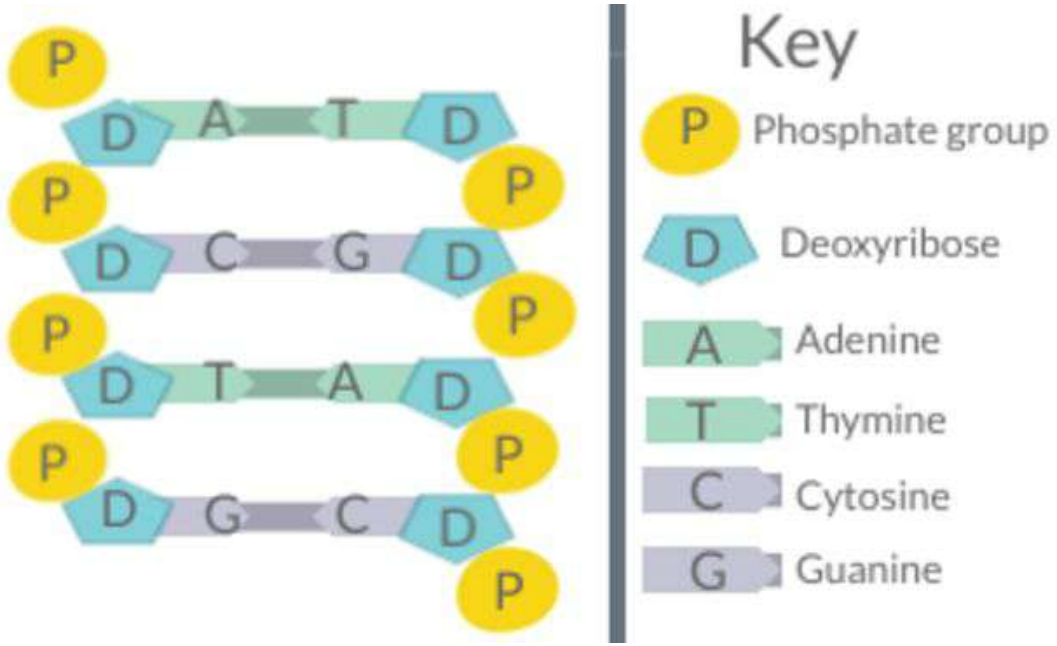
DNA & Genetics

DNA is a polymer, the building blocks of DNA (monomers) are called nucleotides

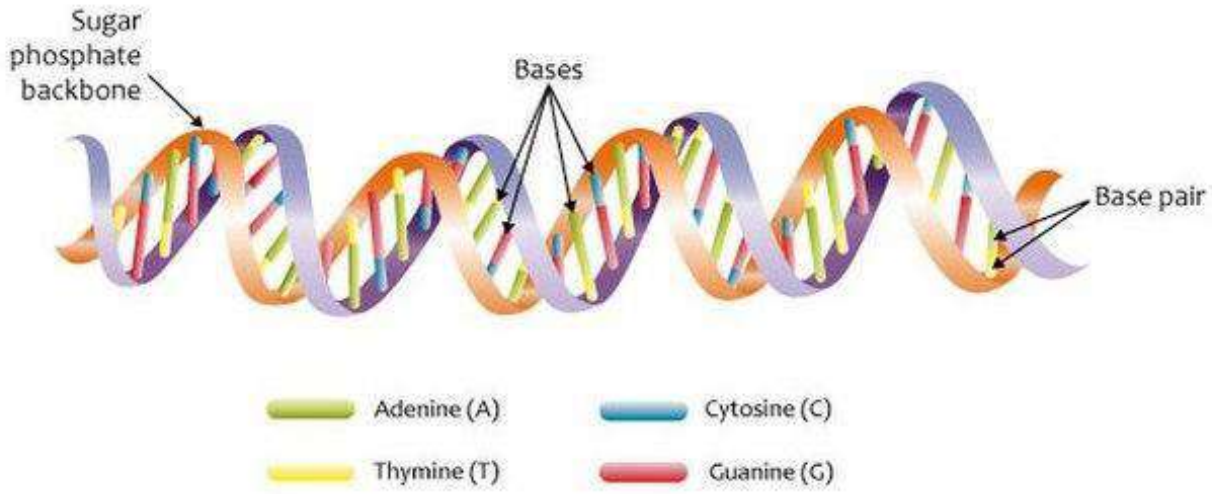
Each nucleotide is comprised of a phosphate group, a deoxyribose sugar molecule, and one of the four nitrogenous bases: adenine (A), guanine (G), cytosine (C) or thymine (T)

A joins to T **C joins to G**

DNA & Genetics

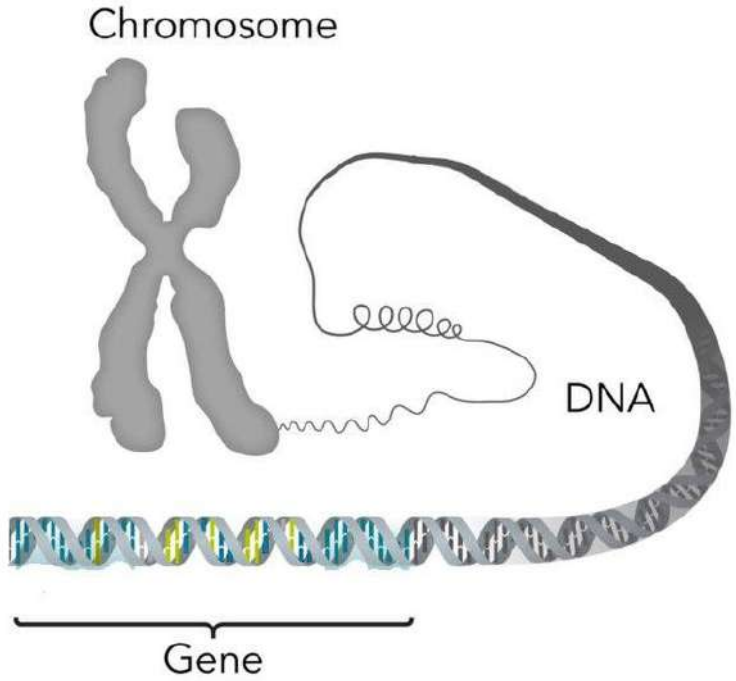


DNA & Genetics



DNA & Genetics

- **Genes** refer to a section of DNA within a specific sequence of nucleotides. It often determines an organism's characteristics and may code for a protein or may not, depending on the gene



DNA & Genetics

- The relationship between DNA, genes and chromosomes

Genetics is the study of inherited characteristics called traits

In natural populations all organisms are genetically different

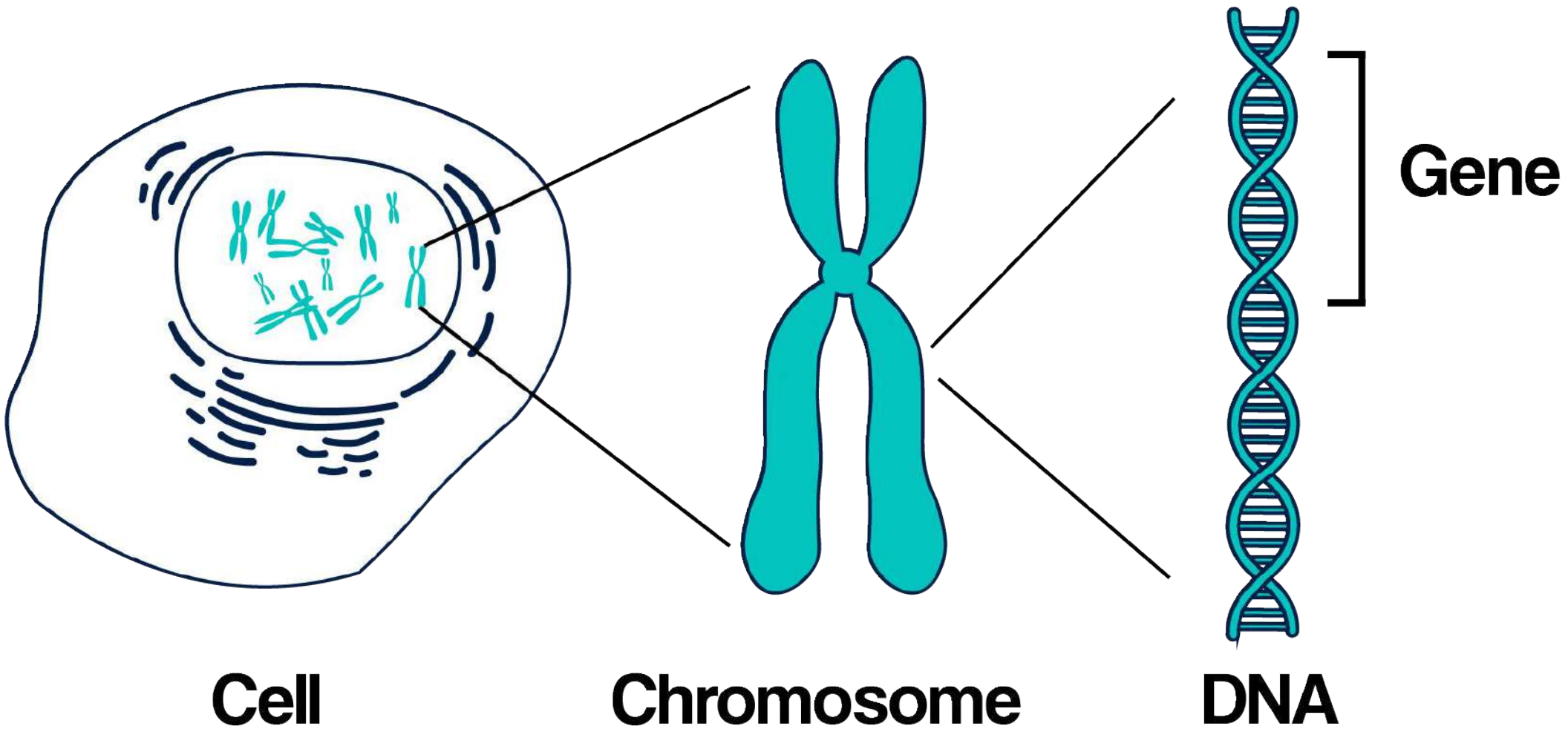
- e.g. different eye colour, hair colour, height, etc.

However, some patterns can be identified in the inheritance of these traits.

Genotype – A set of heritable genes

Phenotype – A characteristic the organism expresses

DNA & Genetics



DNA & Genetics

A common example of a pattern of inheritance is the flower colour of pea plants

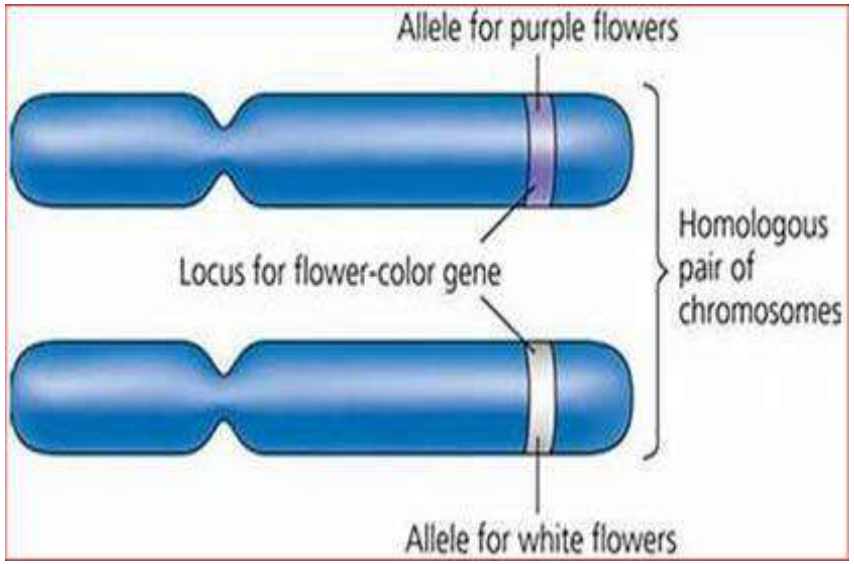
Pea plants can have red flowers or white flowers

The information for flower colour is carried as one of the genes on a homologous pair of chromosomes, and comes in two varieties.

Variations of genes are referred to as **alleles**

DNA & Genetics

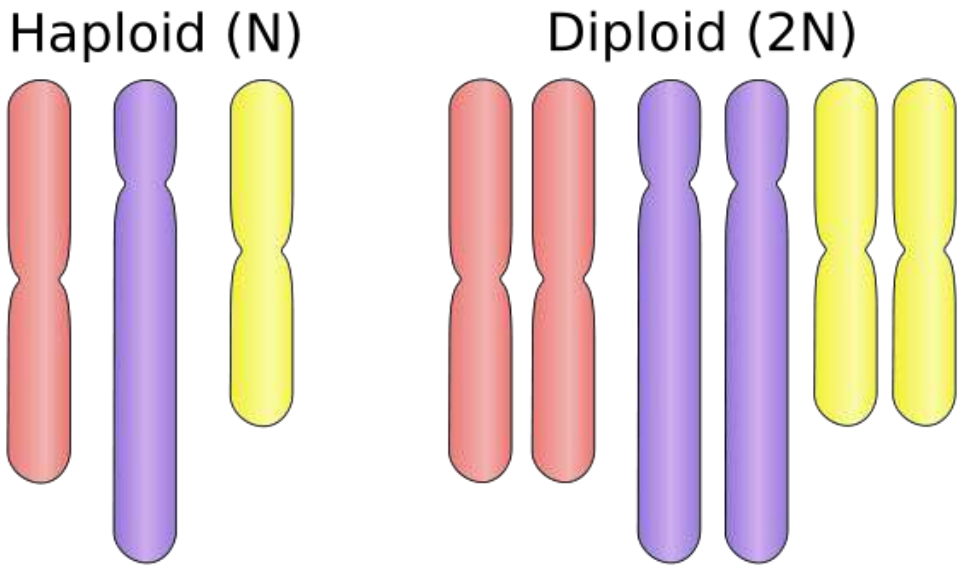
Alleles occupy the same position on a homologous pair of chromosomes.



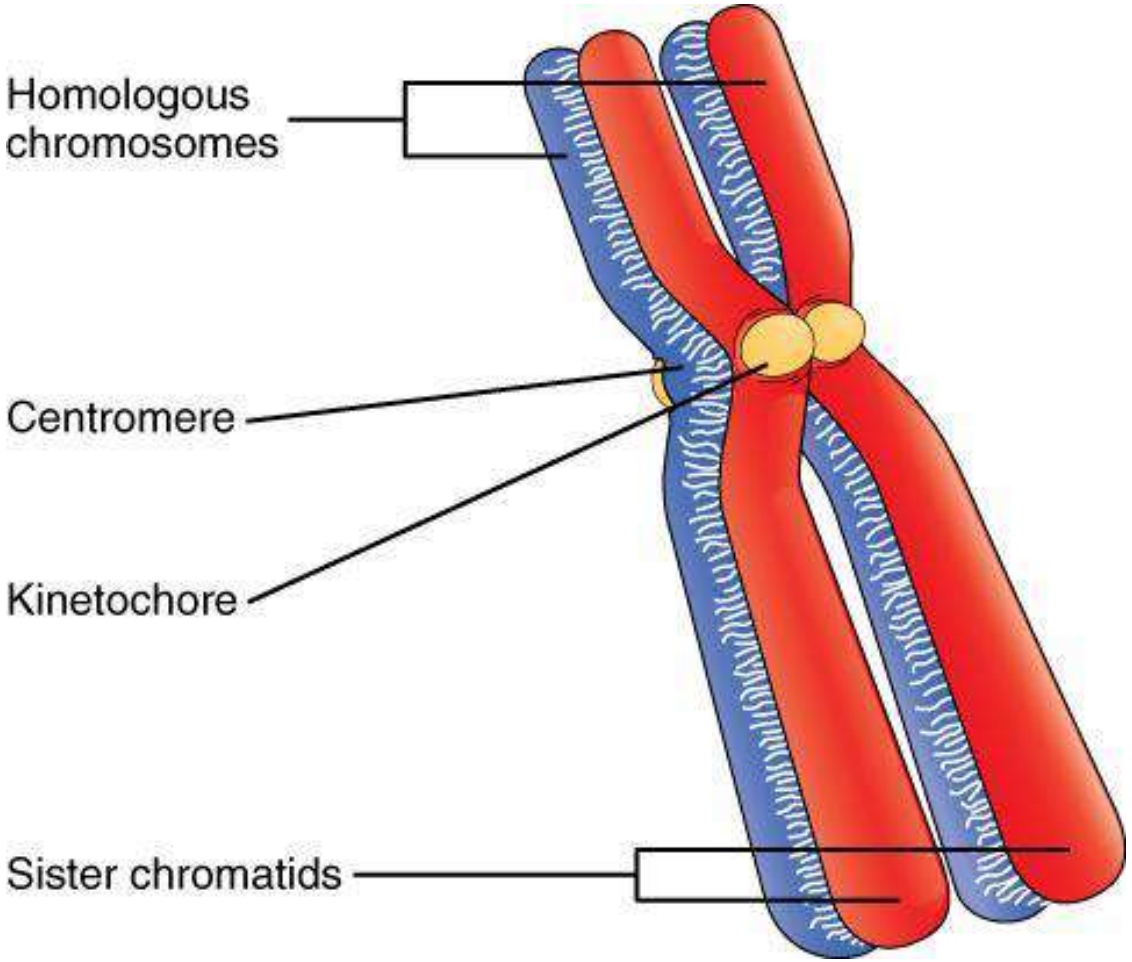
The position of the allele on a chromosome is referred to as a locus

DNA & Genetics

Chromosomes exist in homologous pairs, in humans each somatic cell has 23 pairs of homologous chromosomes, 46 in total



DNA & Genetics



DNA & Genetics

- How do meiosis and fertilisation contribute to DNA?

The process of meiosis produces 4 genetically different cells which have half the number of chromosomes as a normal cell

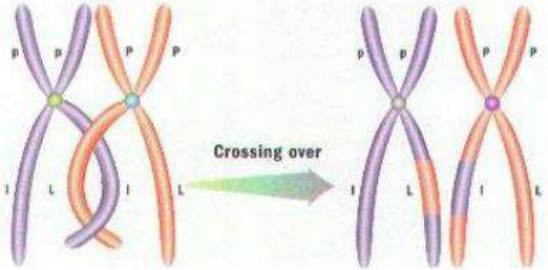
Normal cells with a full set of chromosomes are said to be diploid while the daughter cells produced via the process of meiosis are described as haploid

But how is genetic variation achieved?

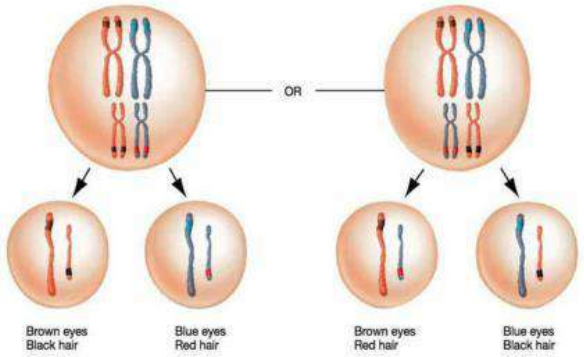
DNA & Genetics

What are the sources of Genetic Variation in Meiosis?

1) **Crossing Over** – crossing over of genetic information of homologous chromosomes during prophase I

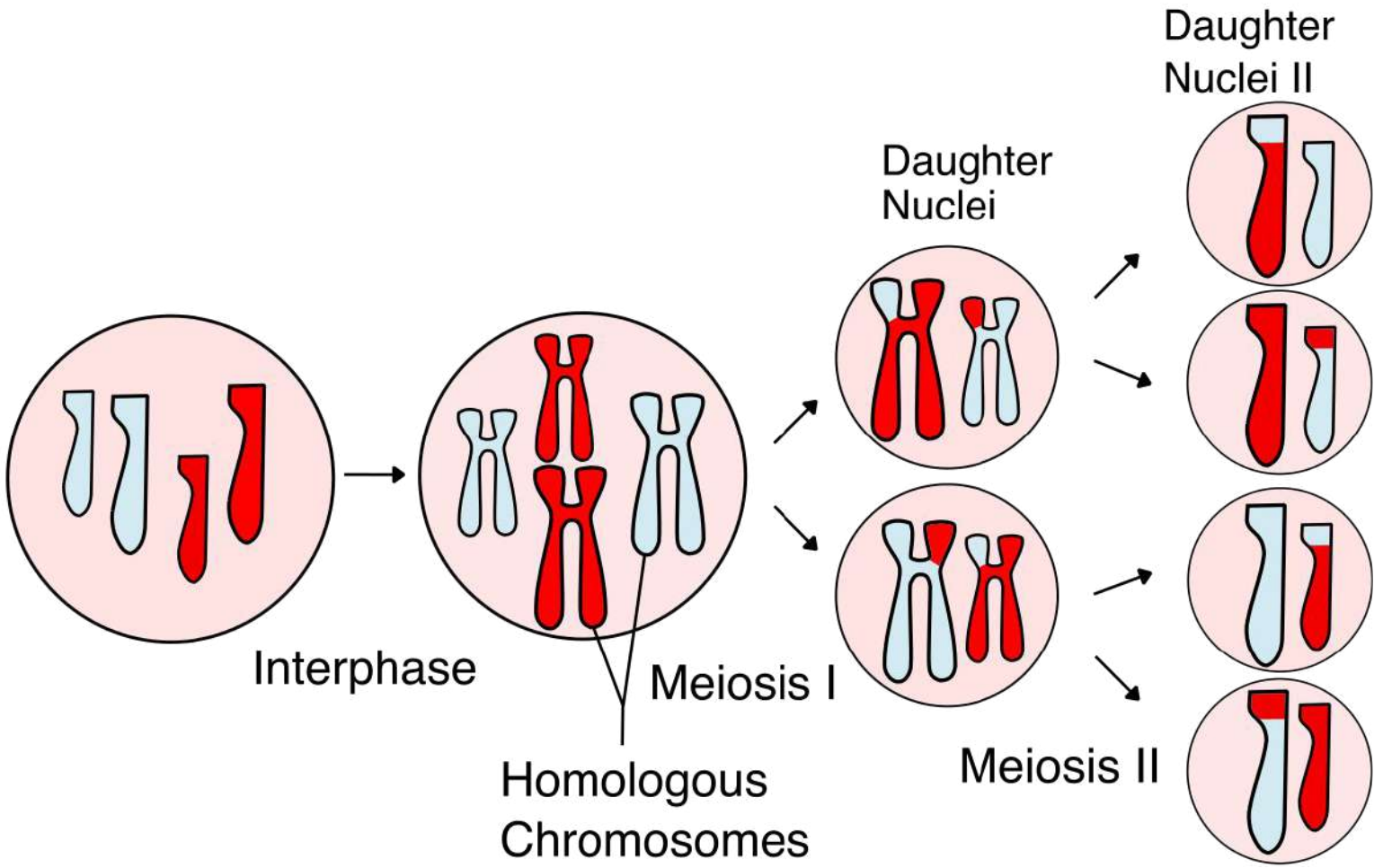


2) **Independent Assortment** – random alignment of maternal/paternal chromosomes during metaphase I



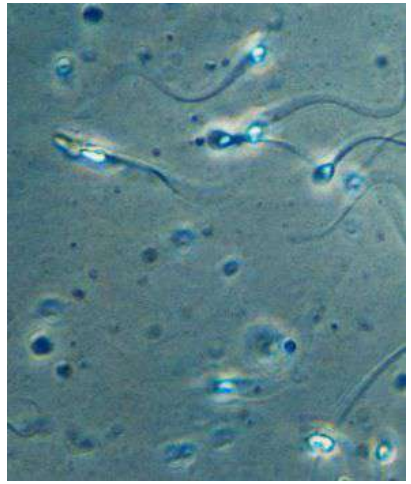
3) **Fertilization** - two gametes (sex cells) coming together to form a zygote

DNA & Genetics



DNA & Genetics

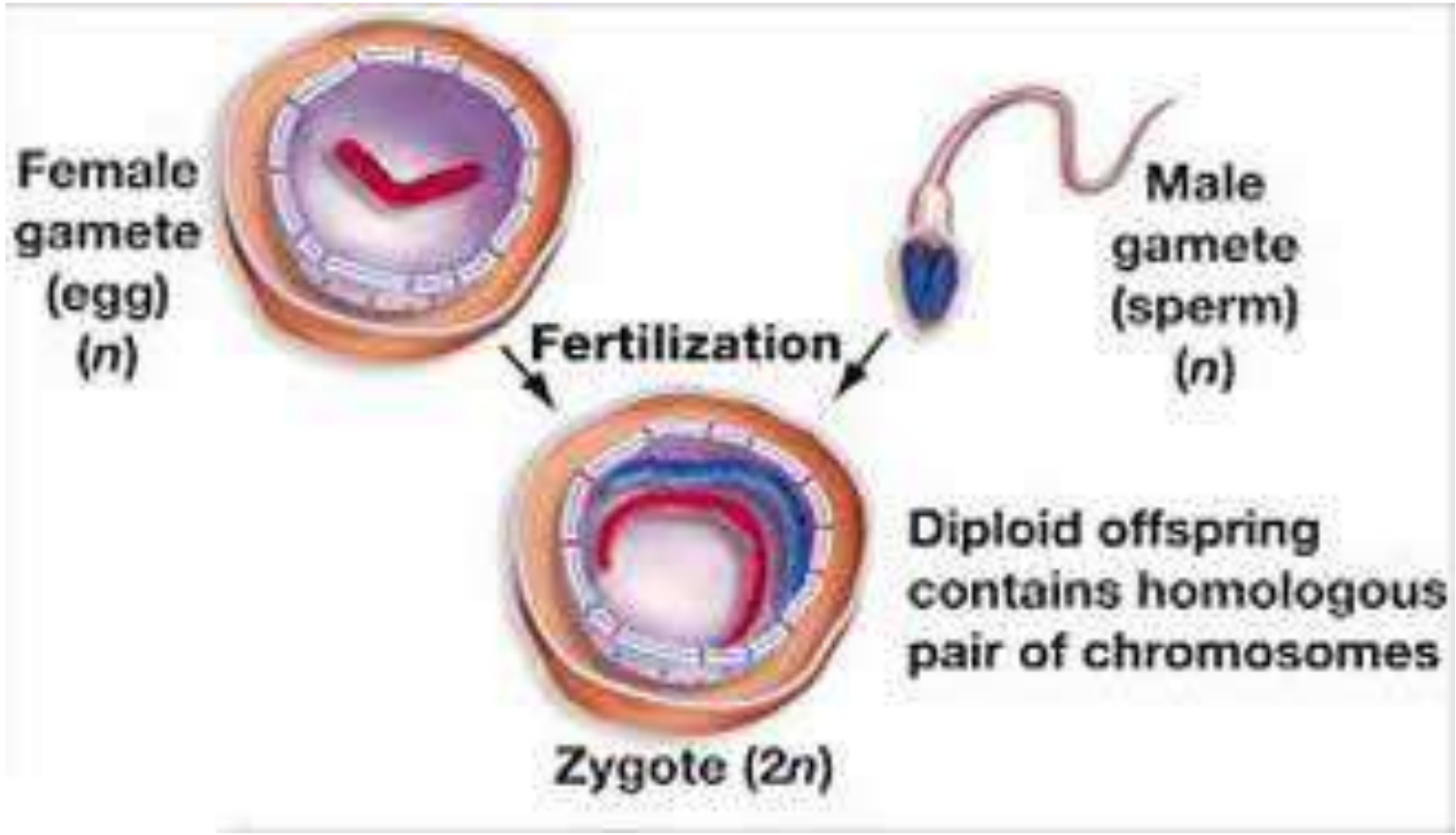
Fertilisation is the process in which haploid gametes fuse to form a diploid cell called a zygote



To ensure that each zygote has the correct number of chromosomes, only one sperm can fuse with one egg

When two haploid gametes, such as a sperm cell and an egg cell, combine they form a diploid zygote which will give rise to an entire organism from a single cell!

DNA & Genetics



DNA & Genetics

Why might it be important for a species to produce offspring with varying characteristics?

DNA & Genetics

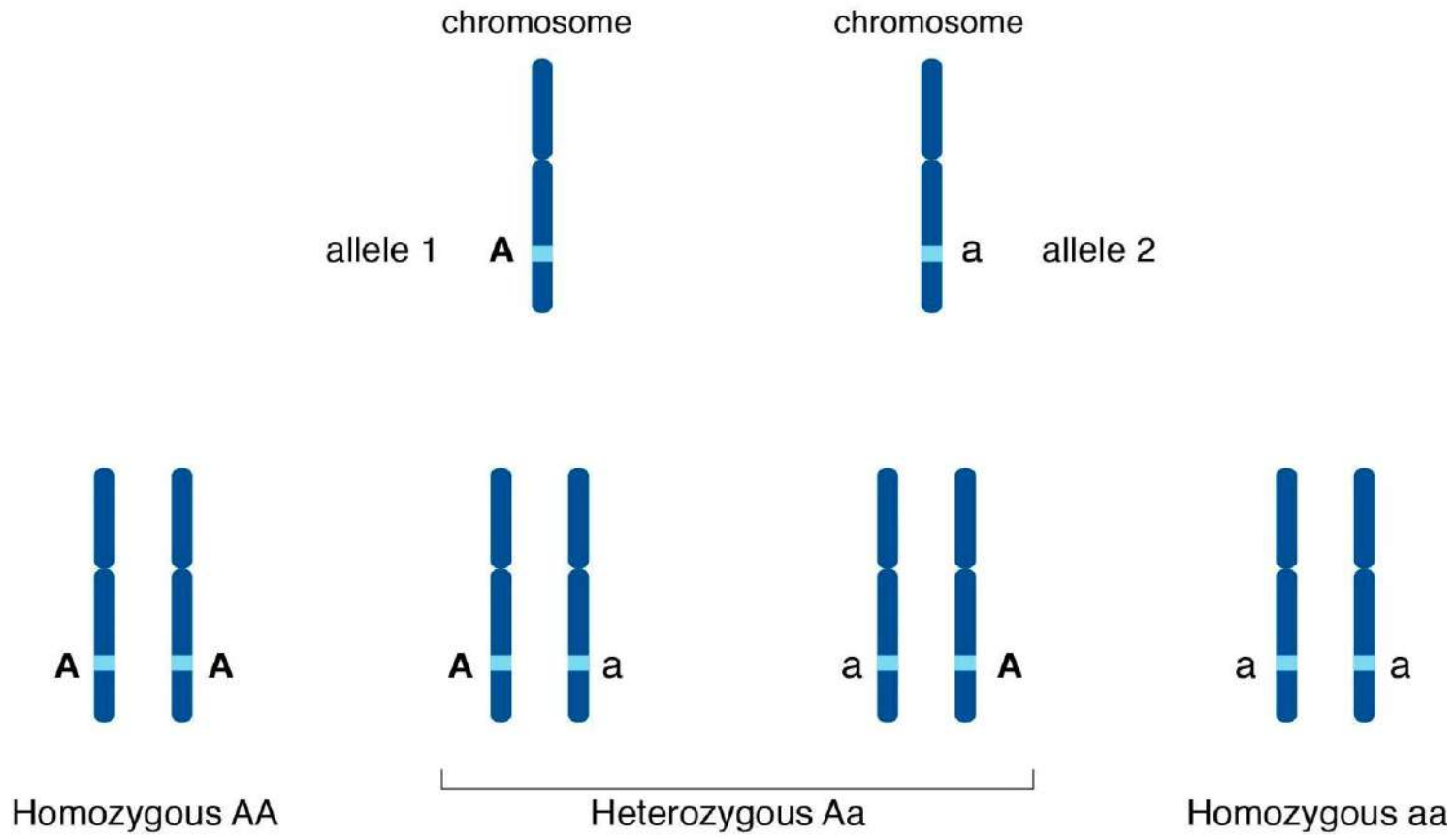
- Patterns of inheritance, dominant and recessive characteristics

Pea-plants can be either red or white

The allele for the red pea-plant can be represented by R

The allele for the white pea-plant can be represented by w

DNA & Genetics



- When an organism has two copies of the same allele it is homozygous
- When an organism has two different alleles it is heterozygous

DNA & Genetics

- Predicting simple ratios of offspring genotypes and phenotypes

A plant breeder has a pure breeding red pea-plant and a pure-breeding white pea-plant. A customer order 100 pea-plants but wants to know what colour the offspring will be. How does the plant breeder know the colour of the offspring?

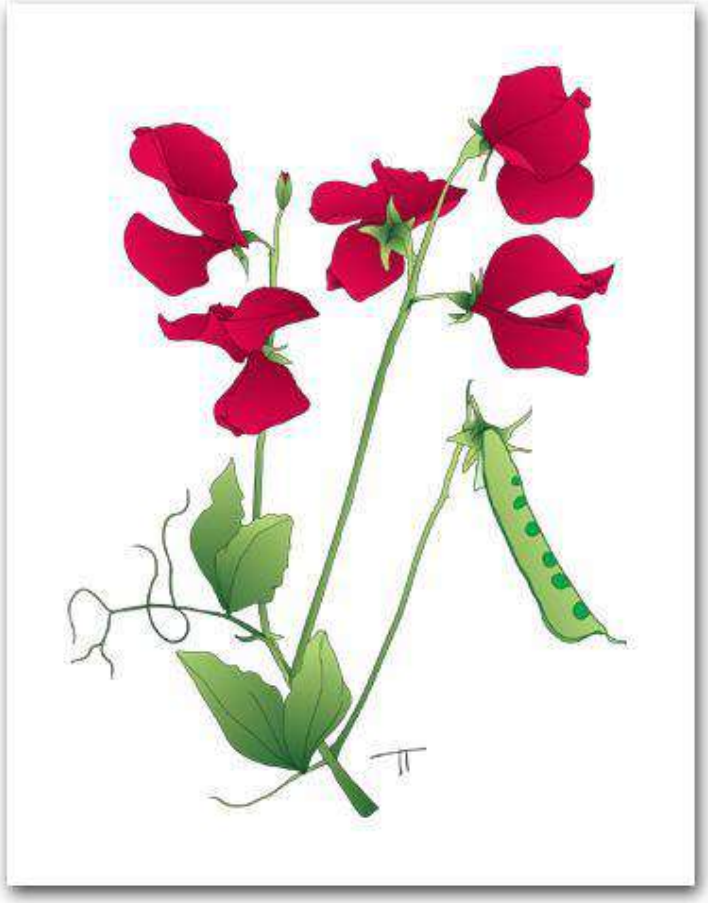
The genotype of a pure-bred red plant can be represented by RR

The genotype of a pure-bred white plant can be represented by ww

DNA & Genetics

The plant-breeder bred the two plants and noticed that all 100 offspring were red

The red trait is dominant over the white trait, the white trait is thus referred to as recessive



DNA & Genetics

Genotype	RR	Rw	ww
Phenotype			

DNA & Genetics

	R	R
W		
W		

DNA & Genetics

- As recessive traits may not always be expressed in the phenotype they can sometimes “skip” a generation

- Blue eye colour is a recessive trait and so you may have blue eyes even if both your parents have brown eyes

- Punnett squares are a useful tool for determining the genotype of the offspring, and therefore the phenotypic ratio

What is the phenotypic and genotypic ratio of the F1 offspring?

	R	W
R		
W		

DNA & Genetics

What is the phenotypic and genotypic ratio of the F1 offspring?

	W	W
R		
W		

DNA & Genetics

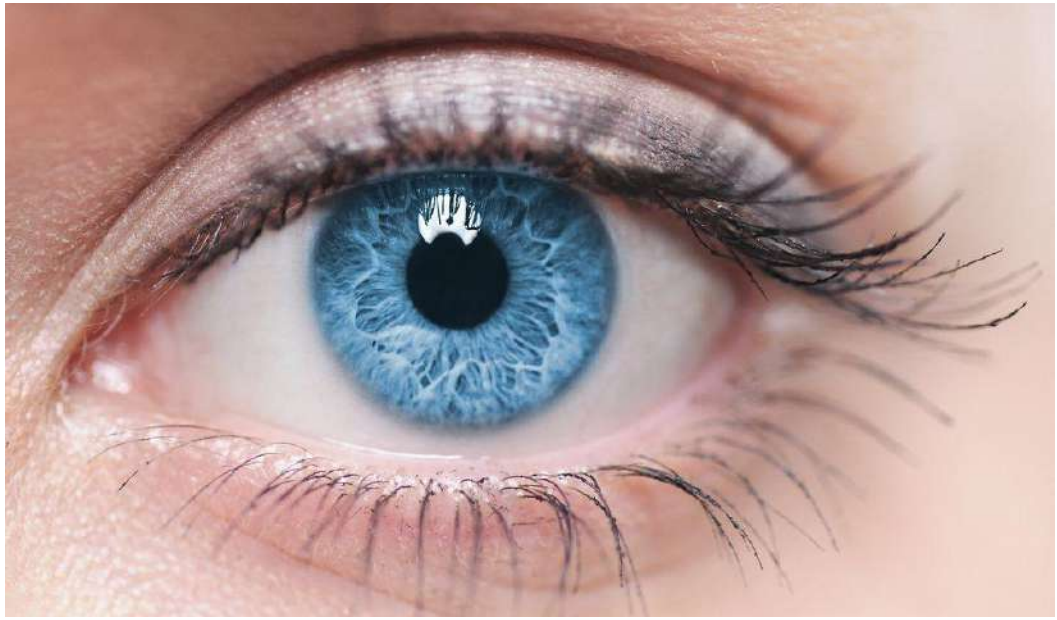
- Mutations as changes in DNA or chromosomes and their contributing factors

Mutations to DNA refer to a change in the genetic code. Mutations can occur spontaneously (not caused by anything) when there are errors in cell division

Quite often these mutations are fixed by the cell but sometimes they are not, most mutations are harmful but they can also have no effect or even be beneficial!

DNA & Genetics

10,000 years ago all humans had brown eyes but a harmless mutation produced the allele for blue coloured eyes! This is likely to have been a spontaneous mutation



DNA & Genetics

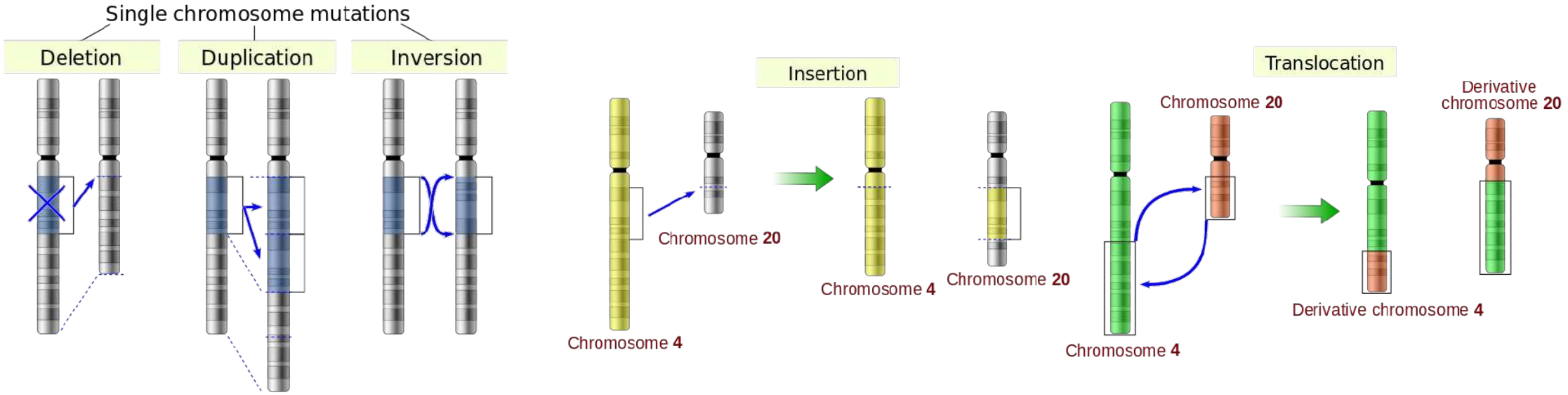
Mutations due to external factors often result in cells dying or becoming cancerous. Two prominent examples include:

UV radiation – Excessive exposure causes mutations that lead to skin cancer.

Carcinogen exposure – Carcinogens are chemicals that cause cancer as they can promote mutations, cigarette smoke contains 70 known cancer causing compounds!

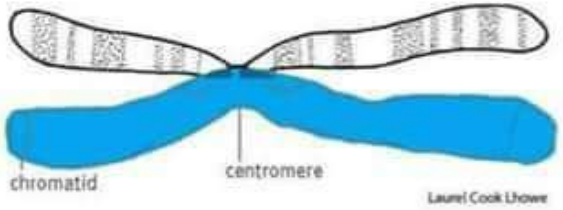
DNA & Genetics

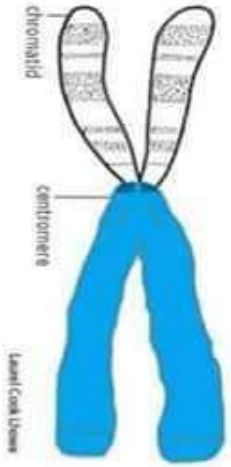
Mutations can also involve changes in segments of chromosomes, sequences of DNA up to thousands of bases long!



DNA & Genetics

If a chromosome wore genes would he wear them like this or like this?





Biological Sciences - Evolution

The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence

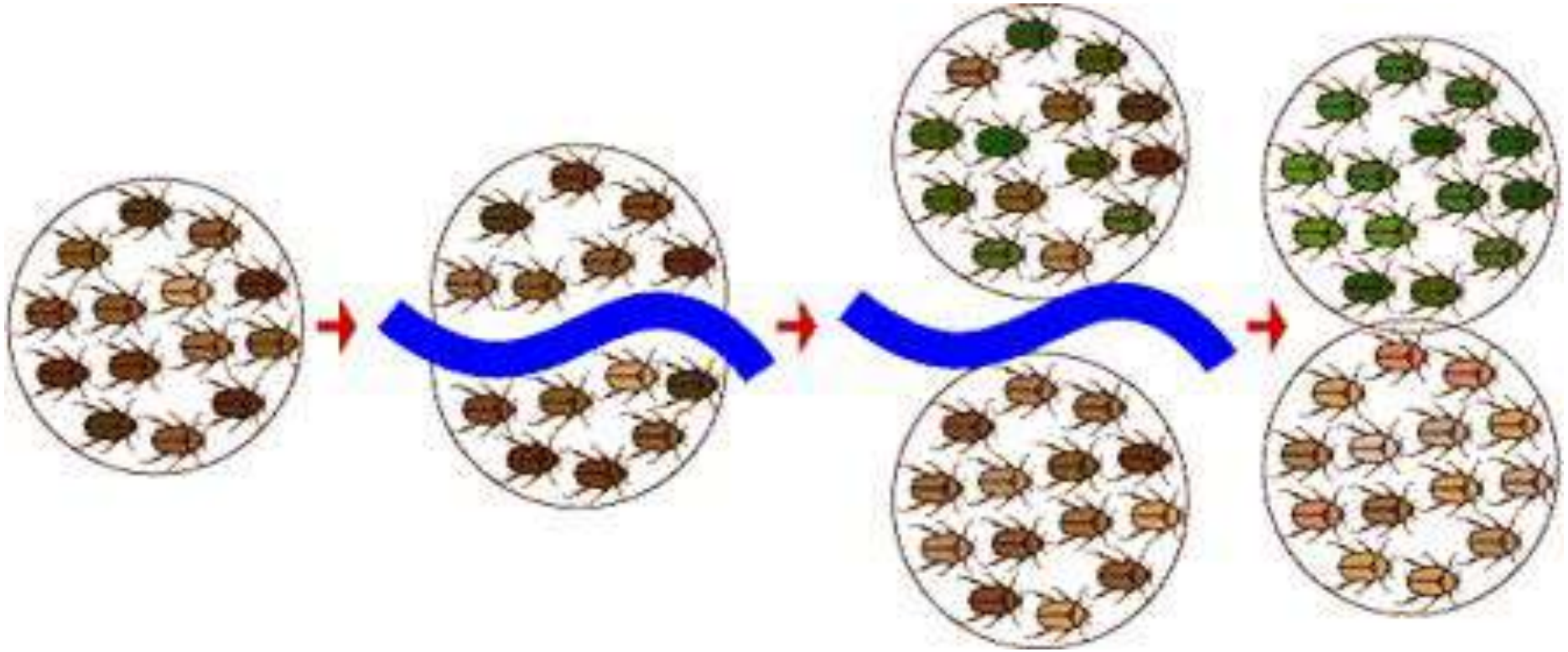
Evolution

- Natural selection - variation, isolation and selection

Variation refers to the differences in genotype that exist within a certain population

If a group within a population is isolated for a long enough period of time with no migration between populations, speciation can occur

Evolution



Evolution

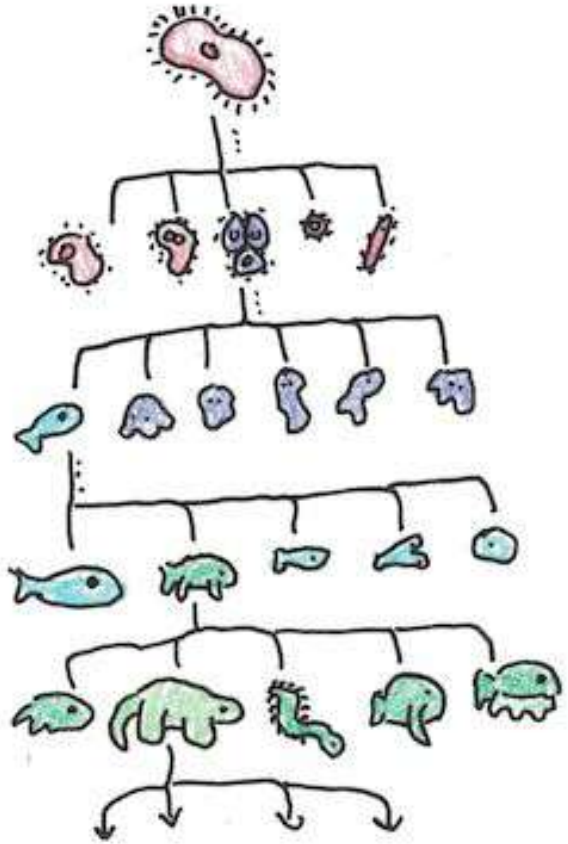
As seen in the previous slide, speciation has occurred! 2 distinct species of beetle have been formed, when members of the different species are brought together they cannot produce viable offspring

Evolution

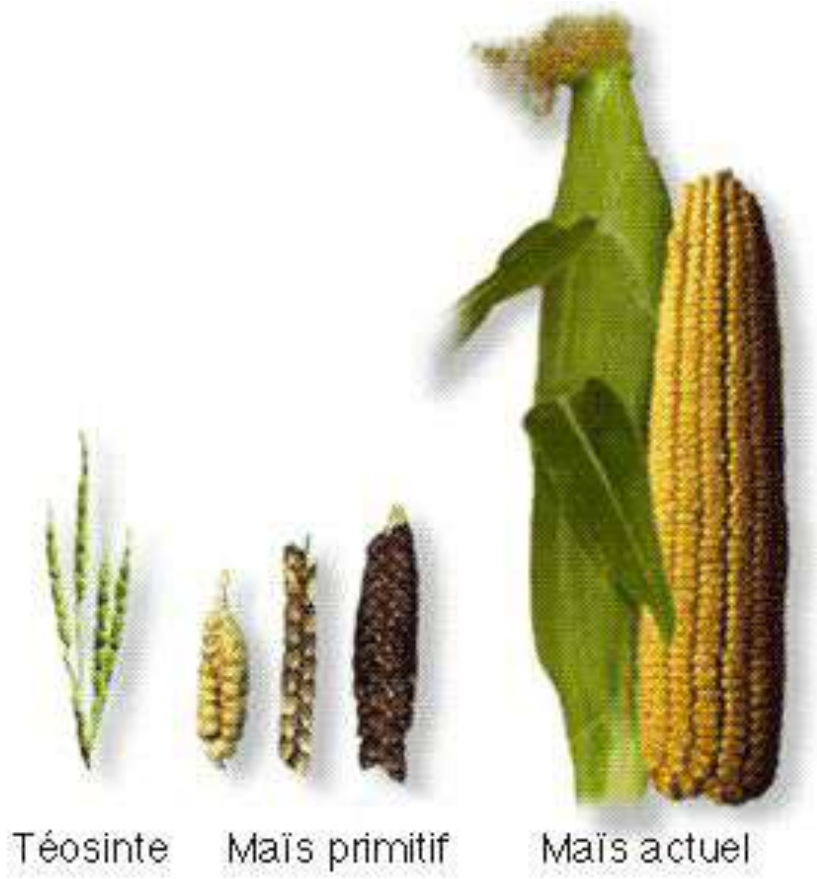
Selection can be either natural or artificial:

Natural selection – The ability for an individual to survive and reproduce in a given environment as influenced by the individual's phenotype

Artificial selection – Also called selective breeding, individuals are chosen to breed by humans based on desired phenotypical characteristics



Evolution



The corn we know and love today didn't always exist, it was produced via the artificial selection of wild grain plants by humans over hundreds of generations!

Next time you're at the movies and enjoying your popcorn, remember that this was made possible by humans in Mexico 7,000 years ago!

Evolution

- Biodiversity as a function of evolution

Biodiversity refers to the variety of life on earth!

Through the process of evolution, different species are produced leading to an increase in biodiversity

As we saw previously, evolution can be facilitated through the process of isolation, selection and speciation!

Evolution

Greater biodiversity ensures greater stability of an ecosystem, some geographical biomes such as coral reefs and rainforests have incredibly rich biodiversity!

Evolution

- Changes caused by natural selection via selection pressures, and artificial selection in breeding for desired characteristics

Selection pressures are factors that influence an organism's ability to survive and reproduce, they can be either biotic or abiotic

Biotic – Influence of other organisms. For example, predators

Abiotic – Influence of environment. For example, temperature

Evolution

In natural selection, organisms with phenotypical characteristics best suited to the niche they occupy are most likely to survive and reproduce and are thus described as having a high genetic fitness

In artificial selection, the organisms that reproduce are chosen by the selector (humans). These characteristics may be desirable for us, but adversely affect an organism. For example, pugs with flat faces often have respiratory problems

Evolution

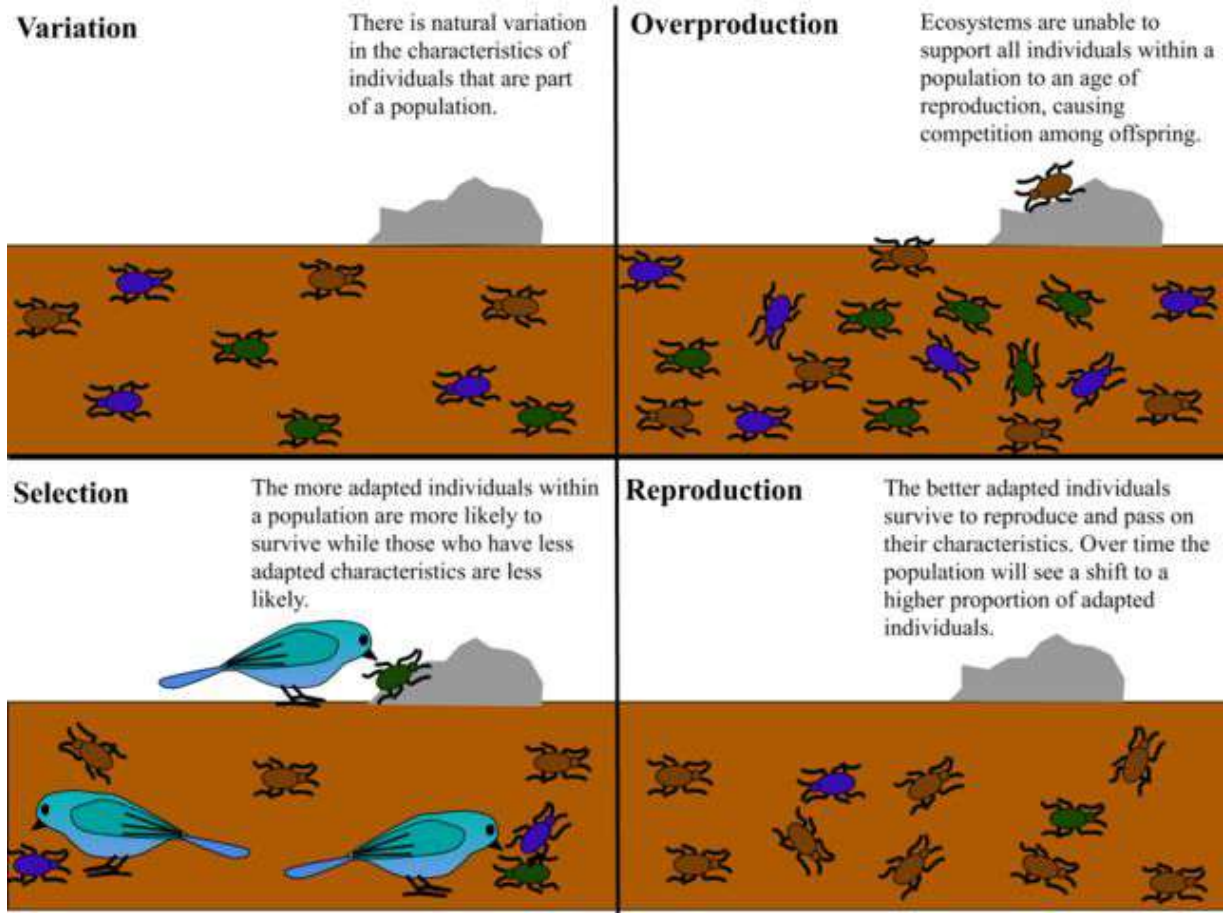
- The influence of genetic characteristics upon survival and reproductive rates

Previously we learnt that the phenotype of an organism is the result of an organism's genotype and environment

Natural selection acts on the phenotype (expressed characteristics) of an organism!

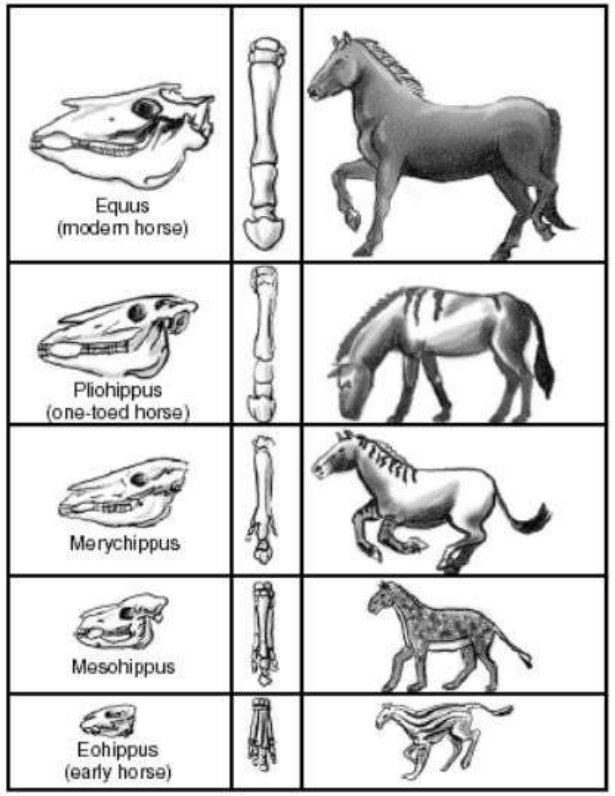
If an organism is more likely to survive, it is more likely to reproduce!

Evolution


Variation
There is natural variation in the characteristics of individuals that are part of a population.
Overproduction
Ecosystems are unable to support all individuals within a population to an age of reproduction, causing competition among offspring.
Selection
The more adapted individuals within a population are more likely to survive while those who have less adapted characteristics are less likely.
Reproduction
The better adapted individuals survive to reproduce and pass on their characteristics. Over time the population will see a shift to a higher proportion of adapted individuals.

Evolution

- The evaluation and interpretation of evidence for evolution, including the fossil record, chemical and anatomical similarities, and the geographical distributio



The fossil record can demonstrate the change over time of a species, when examining the relative age of fossils we can use the core principal of stratigraphy: fossils found deeper are older than the fossils above them in sedimentary layers.

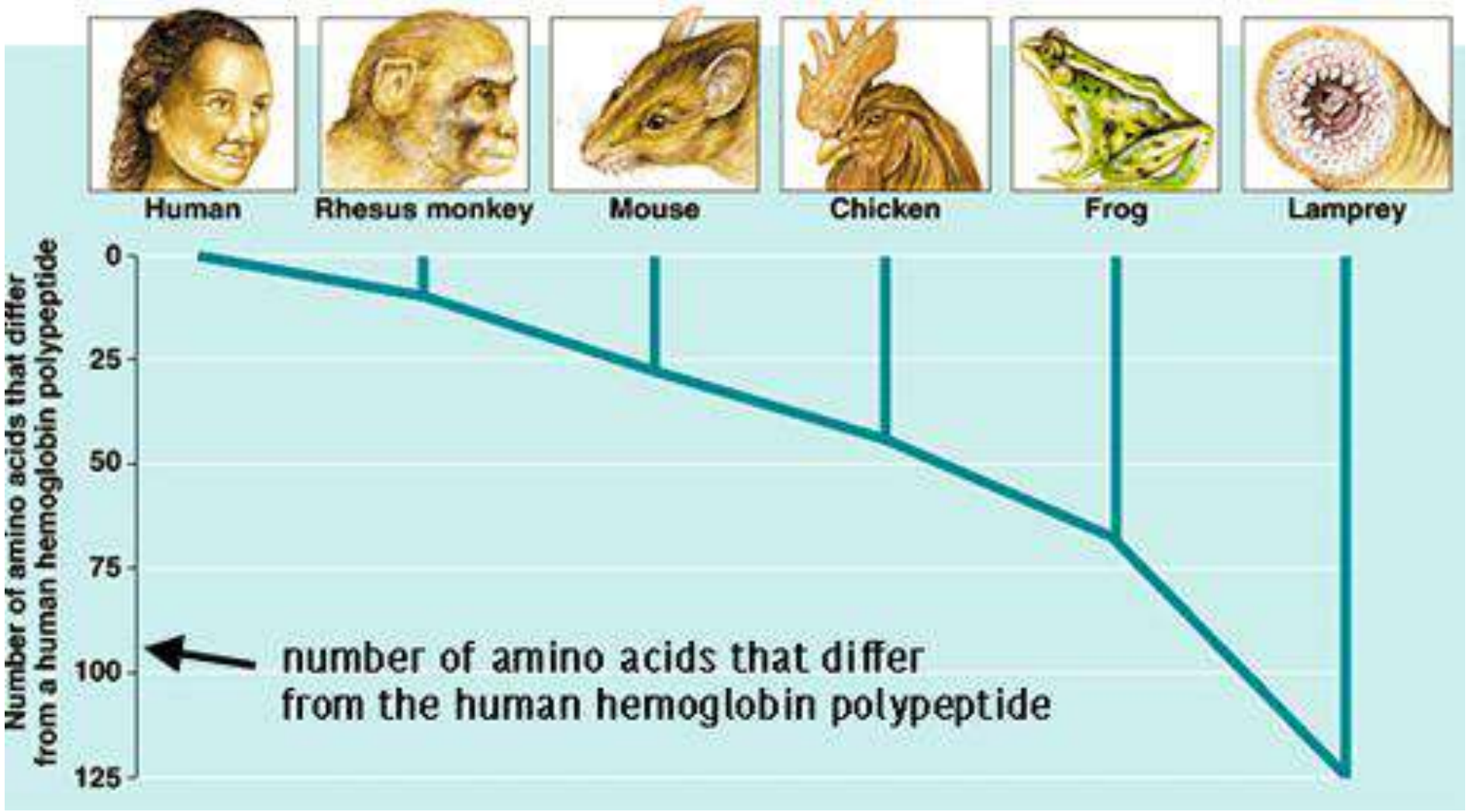
Evolution

The comparison of macromolecules such as nucleic acids and proteins to track evolution is referred to as molecular homology

We track macromolecules that are highly conserved, this means that these molecules are of great importance to an organism and major changes to these molecules may result in death

However over thousands of years small mutations can accumulate, more differences between organisms means that they're more distantly related! We often look at proteins or DNA

Evolution


Human
Rhesus monkey
Mouse
Chicken
Frog
Lamprey
Number of amino acids that differ from a human hemoglobin polypeptide
0
25
50
75
100
125
number of amino acids that differ
from the human hemoglobin polypeptide

Evolution

We can also look at anatomical similarities between organisms but this isn't as accurate as molecular homology. For example, crocodiles and lizards look similar but crocodiles are more closely related to chickens!

Since the mid 19th century, scientists have used comparative embryology to infer evolutionary relationships between organisms. Observing the similarities and differences at different stages of embryo development can show us how closely two species are related. This can only be used for vertebrates as other animals don't develop in the same manner

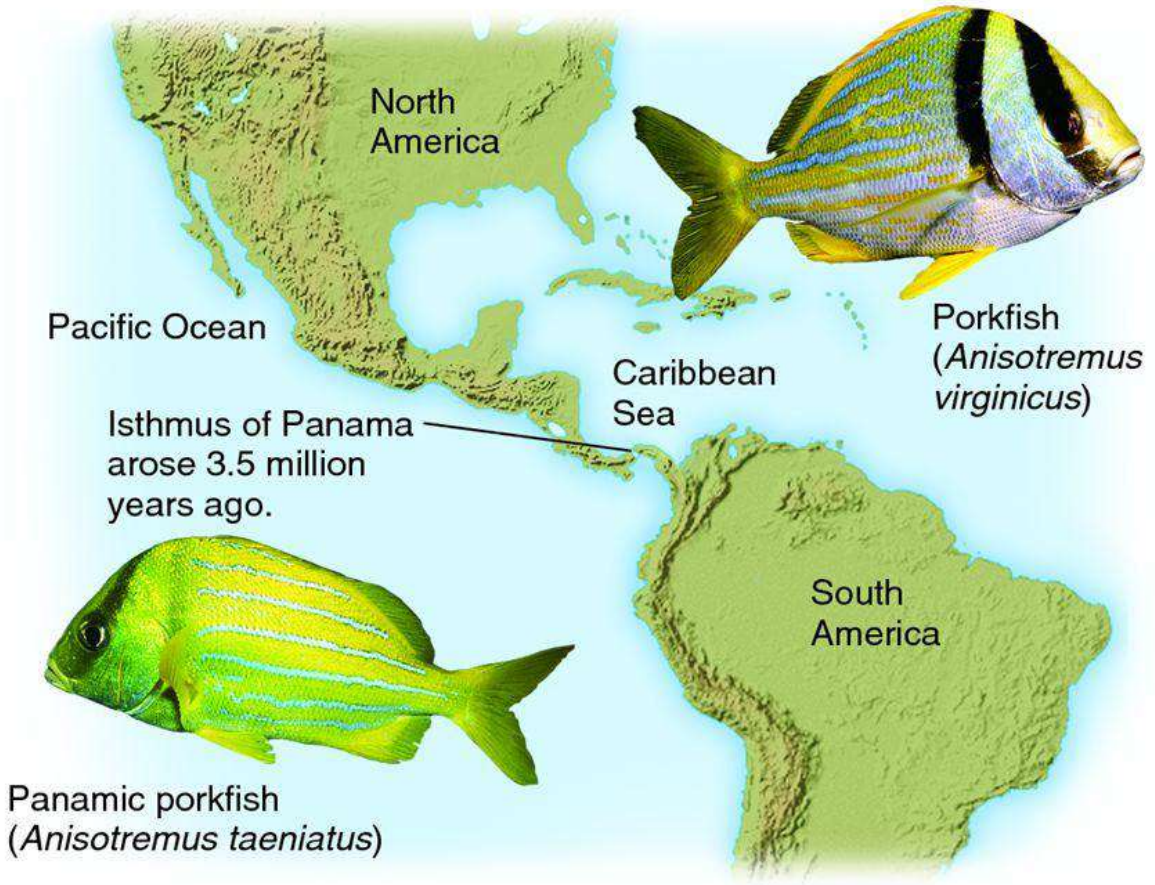
Evolution


Gill slits
Tail
Gills
Gill-slits
Tail
Fore-limb bud
Hind-limb bud
Fish
Sala mander
Tortoise
Chick
Rabbit
Man

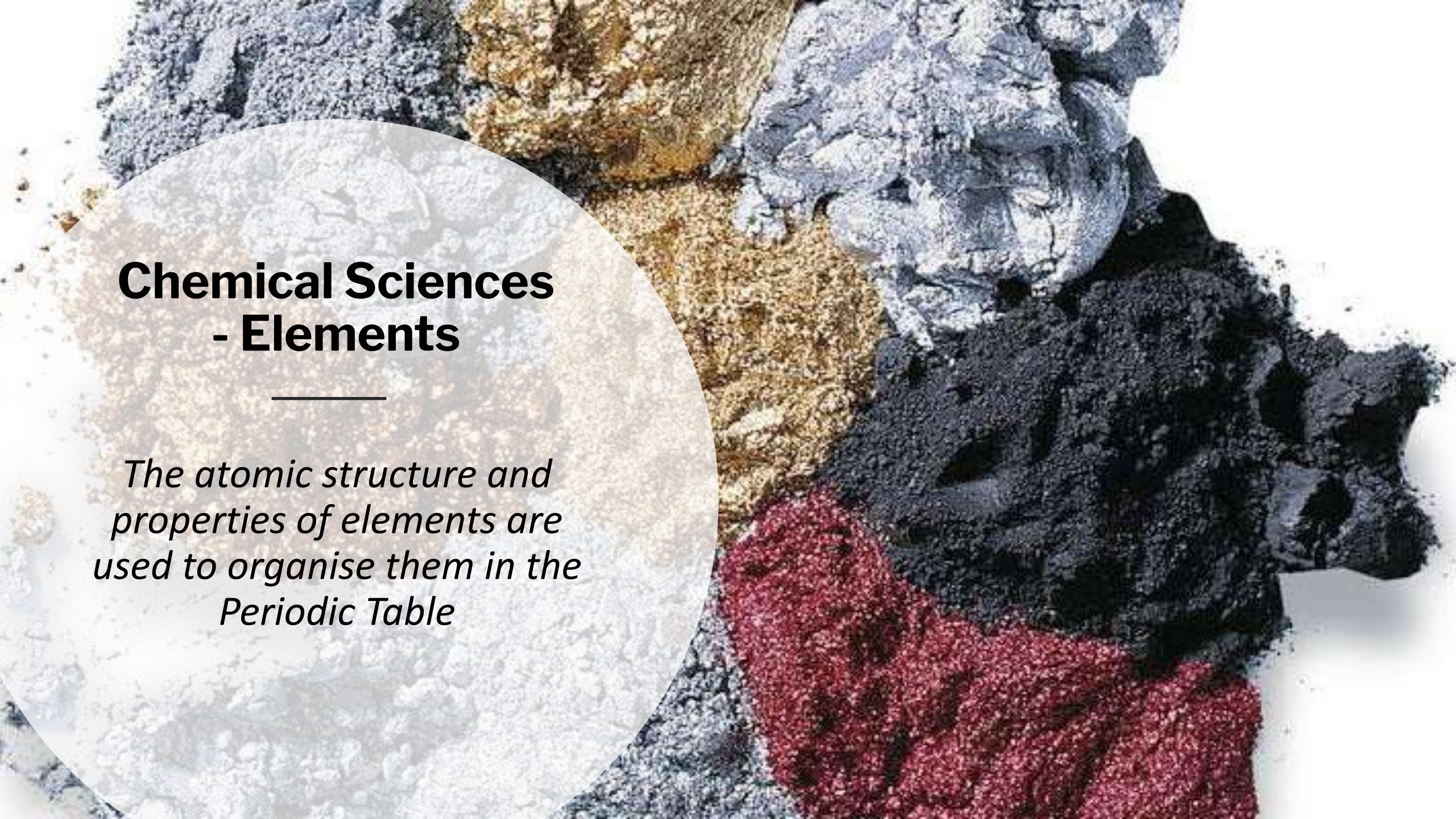
Evolution

Species distribution refers to the geographical area in which a species is present.

By looking at the geographical distribution of closely related species, we can infer what factors may have contributed to speciation!



Evolution



Chemical Sciences - Elements

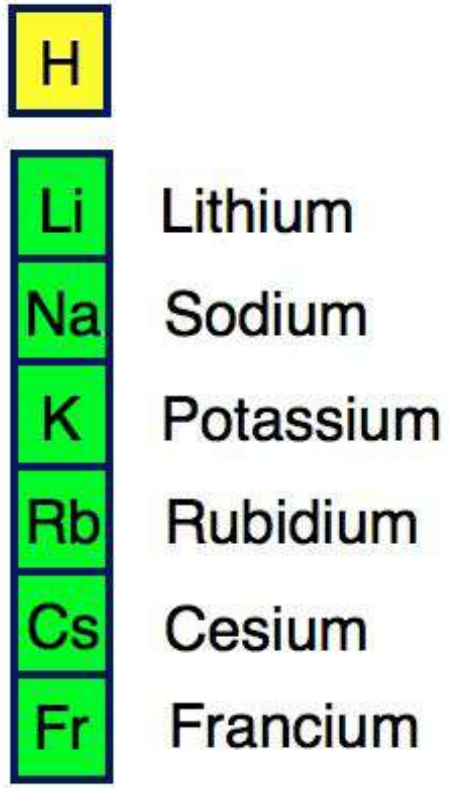
The atomic structure and properties of elements are used to organise them in the Periodic Table

Elements

- The similarities in properties of elements in the same group of the periodic table

Each horizontal row of the periodic table is called a period. The vertical columns are called groups.

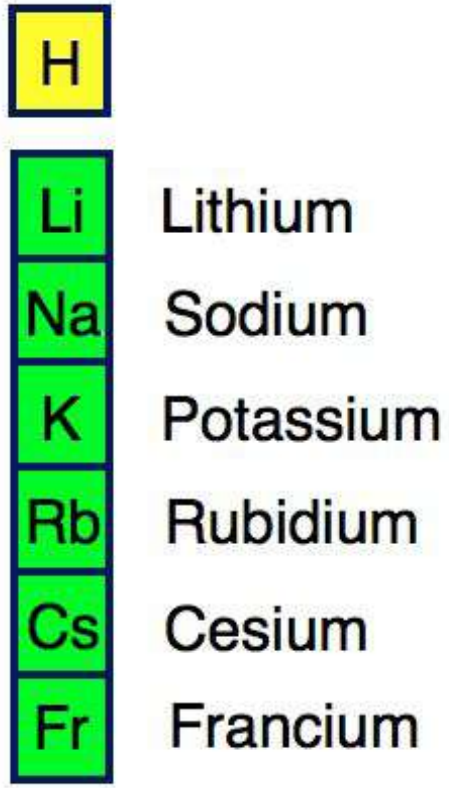
The diagram to the right shows the group one elements!



Elements

Electron structure – The reactivity of an element depends on the structure of its valence electrons. The valence electrons are the electrons within the outer shell of an atom

Cation formation – All of the group one elements have one valence electron, this electron is readily lost. When this happens a metal cation with a charge of +1 is formed



Elements

Elements in the same group generally undergo similar chemical reactions. For example, the group one elements react readily with water in a spectacular display of colours

As you go down a group, the reactivity of an element increases!

To the left, lithium + H_2O

To the right, potassium + + H_2O

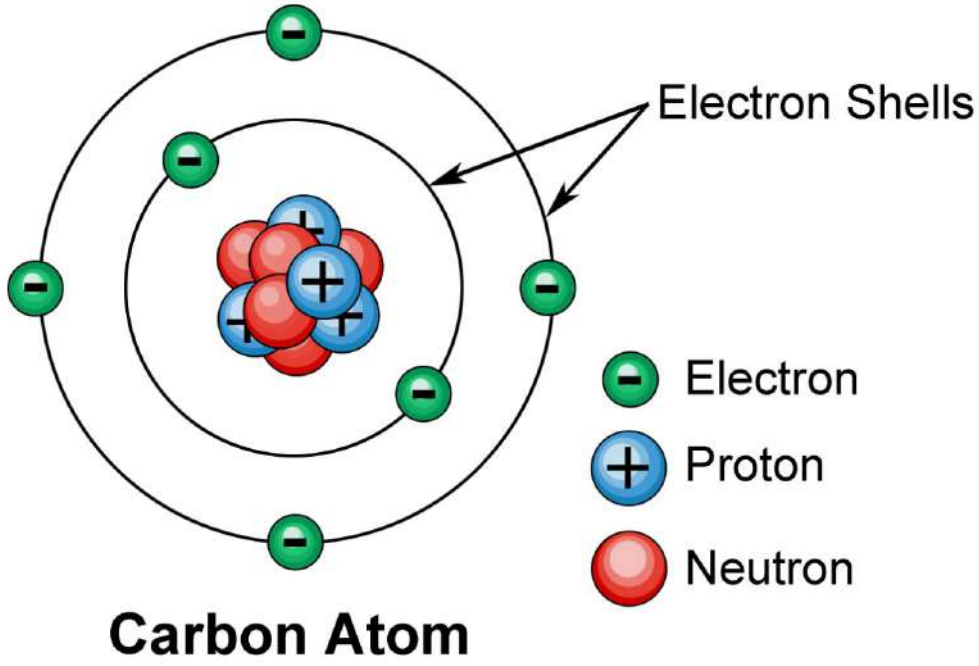
Note that the potassium reaction is much more violent, potassium is lower in group 1 than lithium and is thus more reactive!

Elements

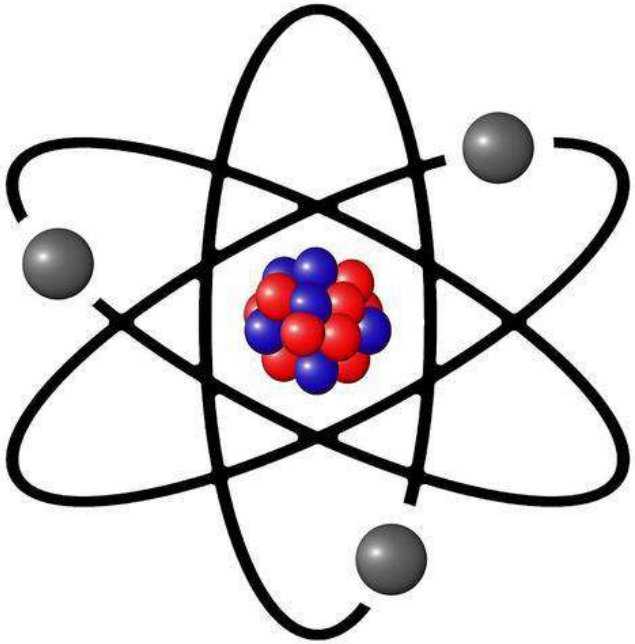
- The structure of atoms - Electron shells

The period (row) of the periodic table that an element is in correlates to the number of electron shells it has

For example, carbon is in period 2 and thus has 2 electron shells.



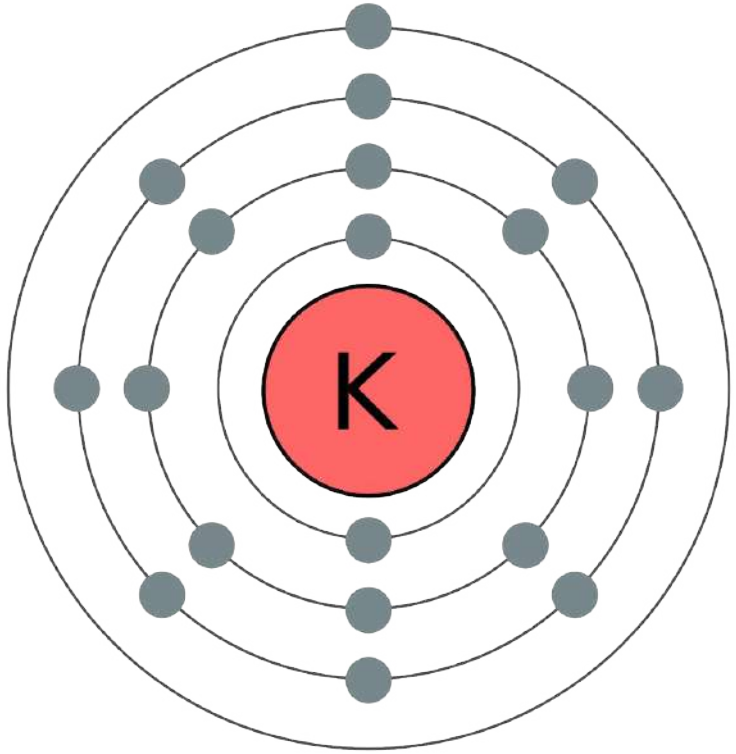
Elements



Electron shells are further subdivided into subshells, these subshells are further subdivided into orbitals

An orbital contains a pair of electrons

Elements



How many orbitals does the 3rd electron shell of potassium contain?

Elements

O and F^- have the same number of electrons

If O and F^- have the same electron configuration, do they have the same chemical properties? Justify your answer!

Elements

- The electronic structure of atoms and how it determines their position in the periodic table and their properties

Core charge is calculated as Z = Protons – non valence electrons

Core charge tells us how strongly the valence electrons are attracted to the nucleus of the atom.

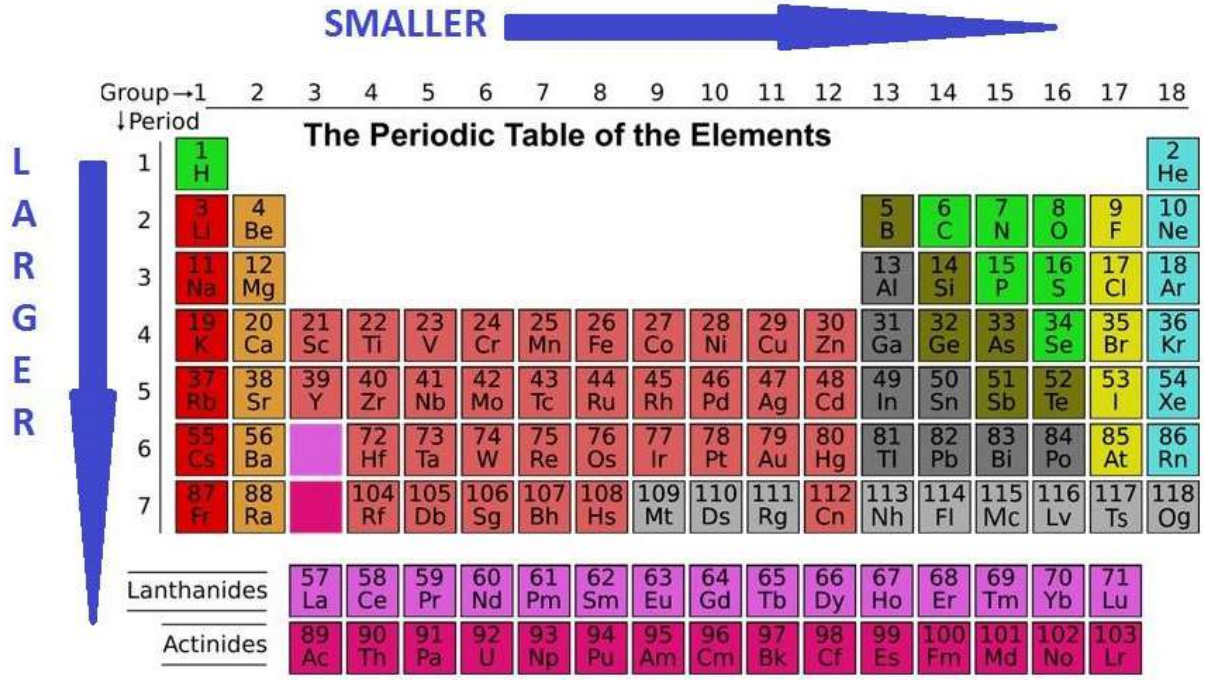
We can use core charge to explain trends in atomic radii

Elements

Atomic radius is the distance between the centre of the nucleus and the outermost electron of an atom

Atomic radius decreases along a period as core charge increases, electrons are pulled closer to nucleus

Atomic radius increases down a group as new electron shells are added



Elements

The electron configuration of atoms also influences their reactivity

Atoms will lose electrons, gain electrons or form covalent bonds (sharing of electrons) to gain a full valence shell of electrons!

The group 18 elements are also called the noble gases, they all have full outer shells and are thus said to be unreactive)

You may have seen fluorescent signs like this one before, they are made with tubes that contain noble gases!

Elements

- The chemical activity of metals

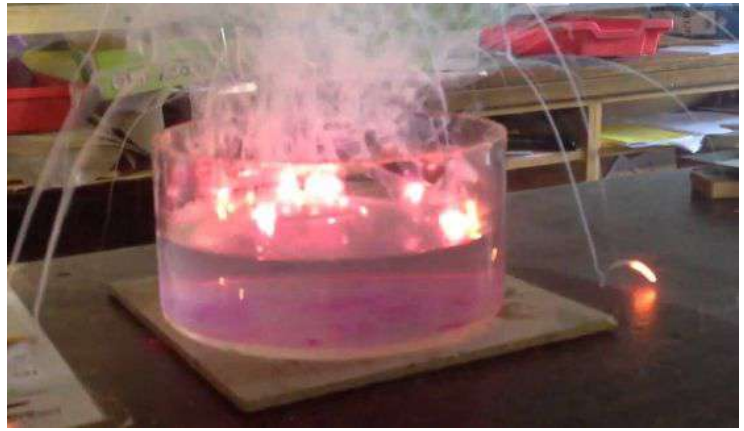
Metal are involved in a variety of chemical reactions but today we'll be focusing on 3 in particular:

1. Metals and water
2. Metals and oxygen
3. Metals and acids

Elements

When metals react with water they form a metal hydroxide and hydrogen gas. An example of this would be the potassium and water reaction that we saw earlier

The products of this reaction would be potassium hydroxide and hydrogen gas



$$2K_{(s)} + 2H_2O_{(l)} \square 2KOH_{(aq)} + H_{2\,(g)}$$

Elements

When metals react with oxygen they form a metal oxide. An example of this would be iron reacting with oxygen gas in the air

The product of this reaction would be iron oxide, this is commonly called rust!

$$4Fe_{(s)} + 3O_{2(g)} \square 2Fe_2O_{3(s)}$$

Elements

When metals react with acids they form an ionic compound (called a salt) and hydrogen gas. An example of this would be magnesium reacting with aqueous hydrochloric acid

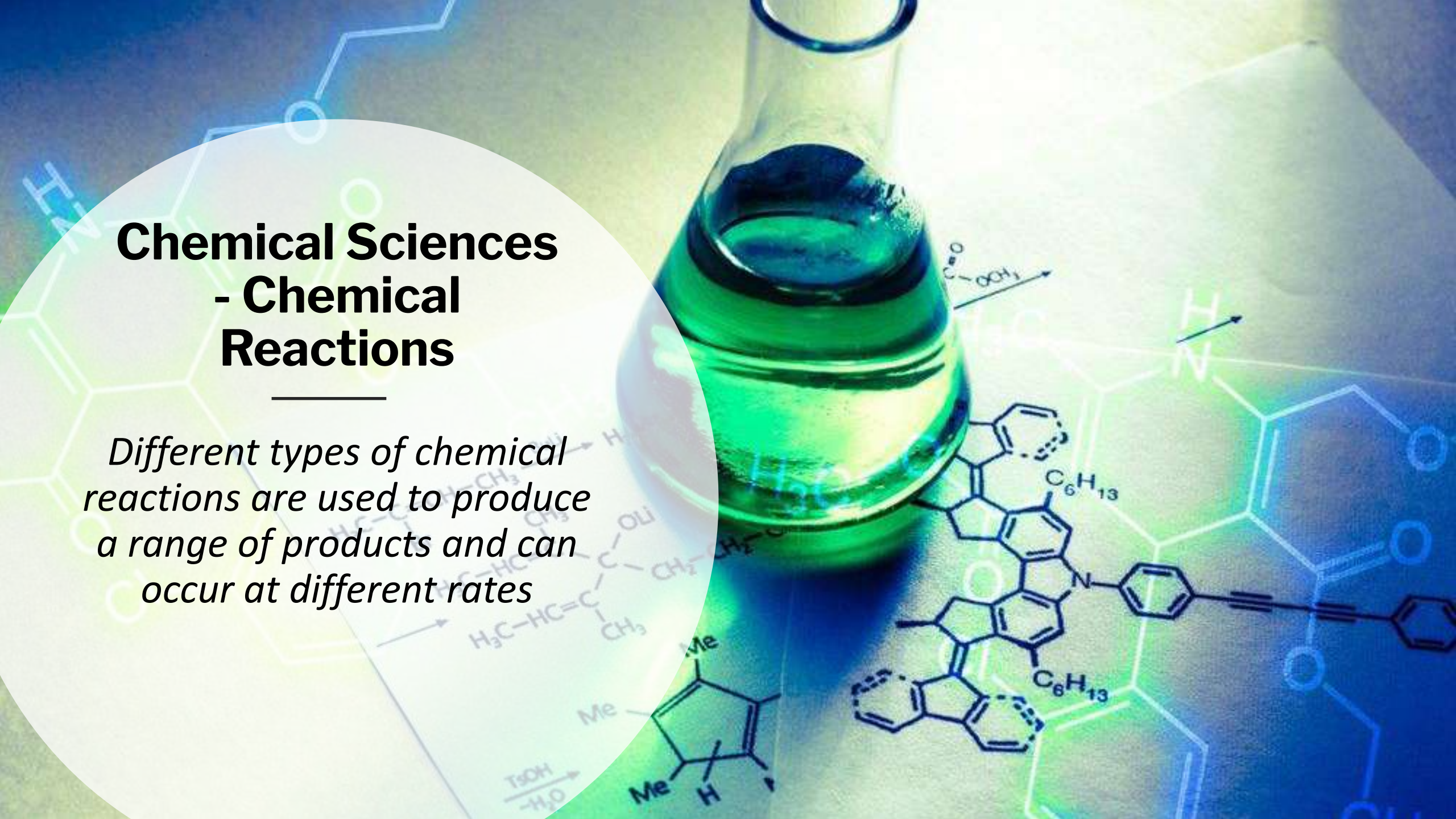
The products of this reaction would be magnesium chloride and hydrogen gas

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

Elements

Chemical Sciences - Chemical Reactions

Different types of chemical reactions are used to produce a range of products and can occur at different rates

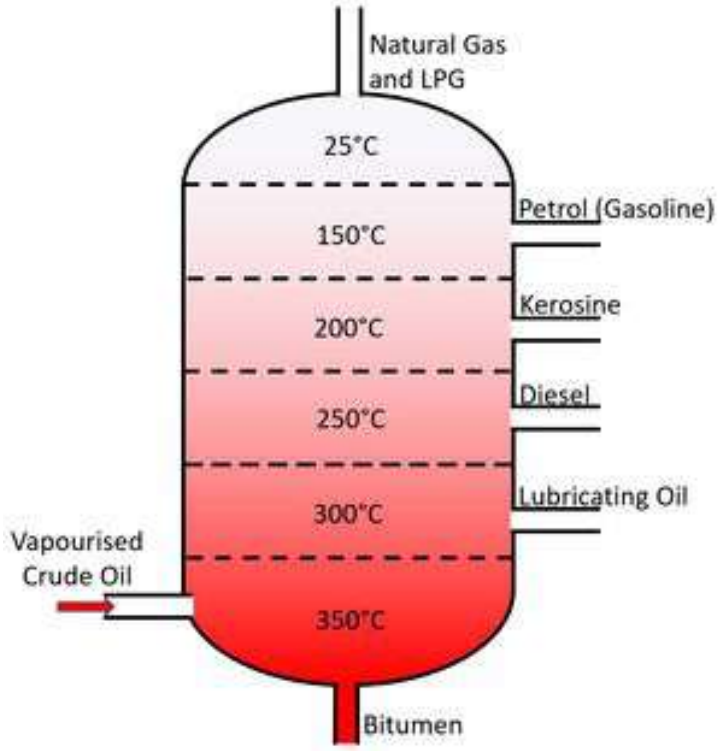


Chemical Reactions

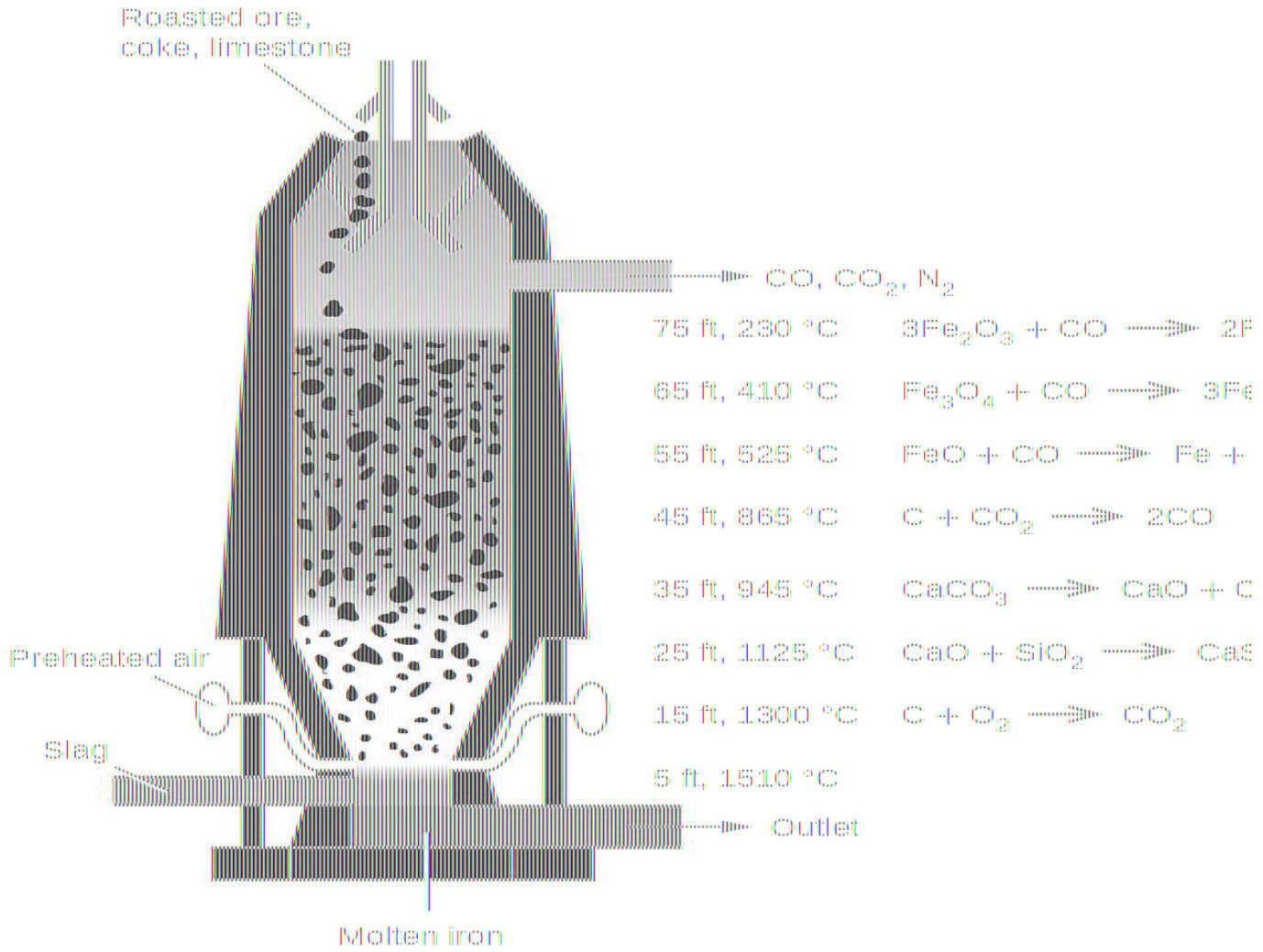
- How can chemistry be used to produce a range of useful substances such as fuels, metals and pharmaceuticals?

Crude oil is extracted from beneath the earth's surface, it contains a mixture of different hydrocarbons. As different chemicals have different boiling points, we can separate crude oil into it's components!

Let's look at some of the products on the diagram and discuss their uses!



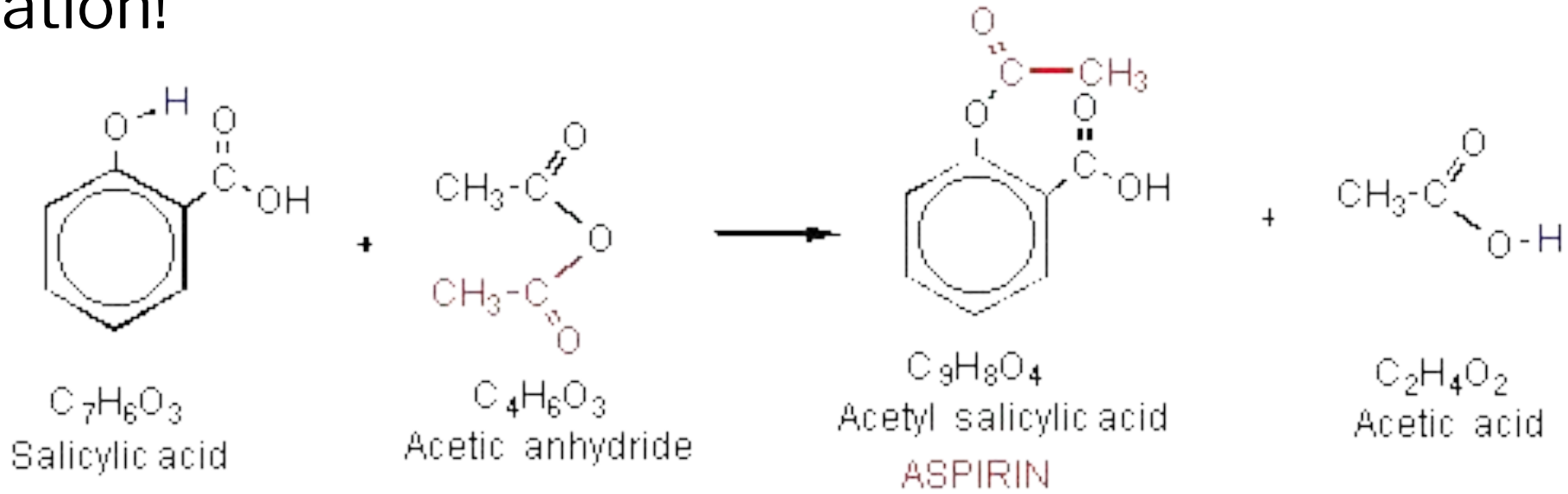
Chemical Reactions



We also use chemistry to refine metal ores into pure metals, iron is produced through a sequence of chemical reactions!

Chemical Reactions

We can also use chemical reactions to make pharmaceuticals. An awesome example is the production of Aspirin, a pain medication!



This reaction is sped up by a catalyst, we'll talk about those soon!

Chemical Reactions

- Predicting the products of different types of simple chemical reactions

Synthesis :

Decomposition:

Single replacement:

Double replacement:

Chemical Reactions

From the previous slides we identified 4 basic types of chemical reactions, can you match the type of reaction to the examples below?

a) $Mg_{(s)} + CuSO_{4\,(aq)} \rightarrow Cu_{(s)} + MgSO_{4\,(aq)}$

b) $CaCO_{3\,(s)} \rightarrow CaO_{(s)} + CO_{2\,(g)}$

c) $2K_{(s)} + Cl_{2\,(g)} \rightarrow 2KCl_{(s)}$

d) $NaCl_{(aq)} + AgNO_{3\,(aq)} \rightarrow AgCl_{(s)} + NaNO_{3\,(aq)}$

Chemical Reactions

- Using word or symbol equations to represent chemical reactions

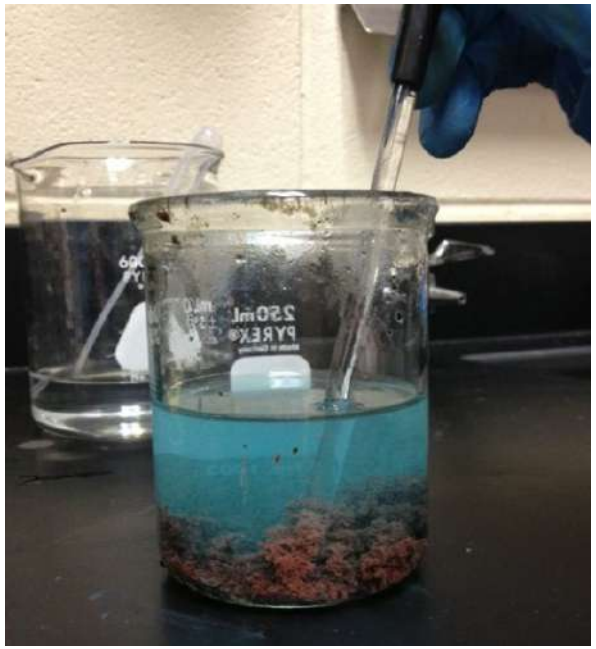
In chemistry we can chose to represent equations using words or symbols, many students lose marks in tests because they write out the wrong form of the equation! Don't forget to refer to states too!

It's a good idea to underline the type of equation being asked for in a question, whether that be the word or symbol equation

Chemical Reactions

Word equation:

Magnesium metal + copper sulphate solution Copper metal + magnesium sulphate solution



Symbol equation:

$Mg_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + MgSO_{4(aq)}$

Chemical Reactions

- How do temperature and catalysts effect the rate of chemical reactions?

Increasing the temperature or adding a catalyst will increase the speed of a chemical reaction

In chemistry, a catalyst is a substance that speeds up a chemical reaction without being consumed in the reaction itself – it is not a reactant! Inorganic catalysts usually contain transition metals

Chemical Reactions

Temperature

To understand why temperature increases reaction rate, we need to look at kinetic particle theory. It states that particles are constantly moving and for a reaction to happen the reactant particles need to collide in the correct orientation

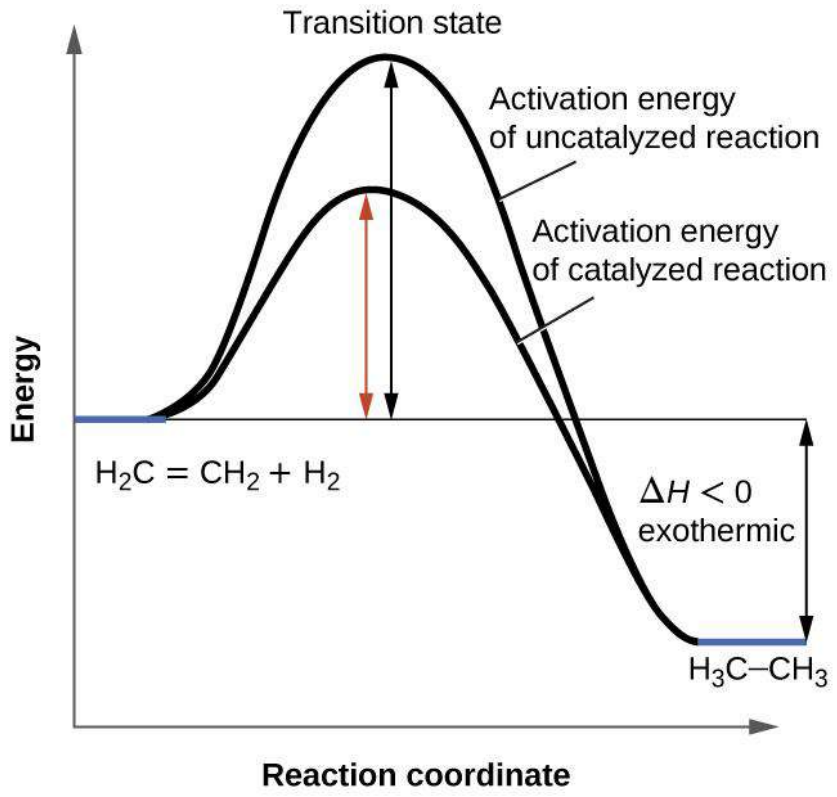
If we increase temperature, the particles have more kinetic energy (move faster) so more successful collisions occur and thus the reaction is sped up!

Chemical Reactions

Catalysts

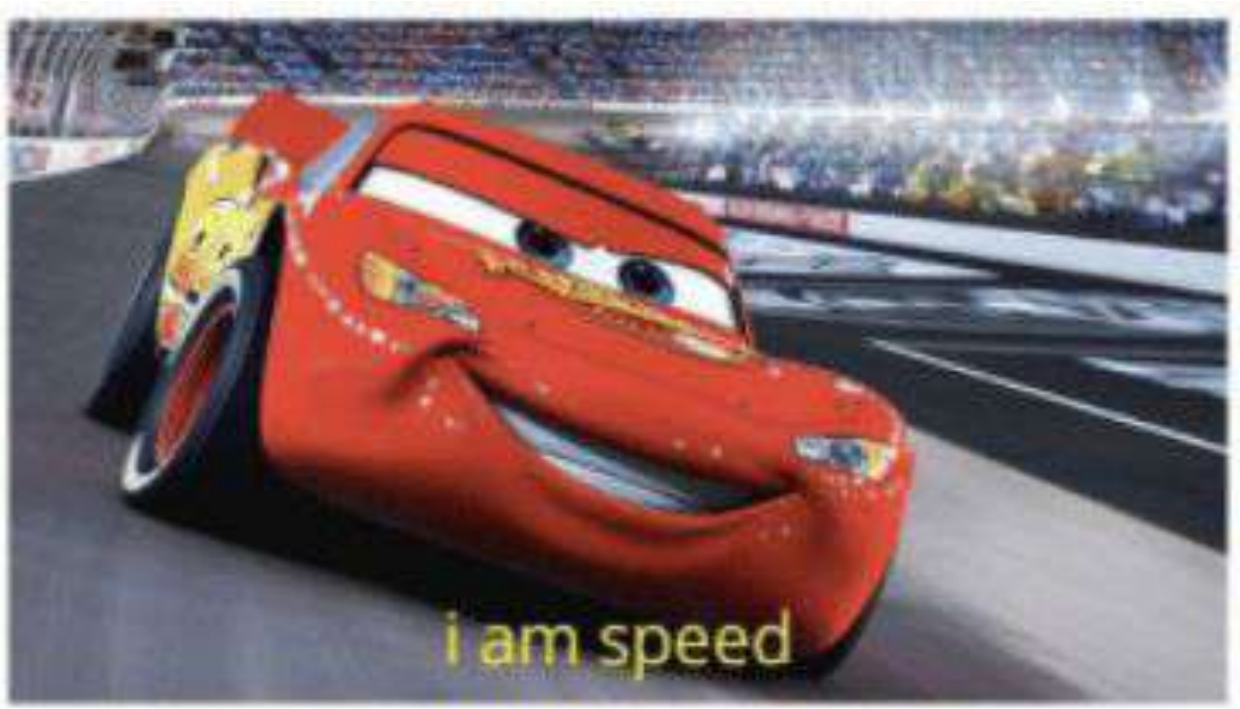
Activation energy is the amount of energy that must be present in a chemical system for a potential reaction to occur

A catalyst speeds up a chemical reaction by lowering the activation energy of a chemical reaction, by providing an alternative reaction pathway



Chemical Reactions

Chemical reactions when a catalyst is added:



Thank you for attending and best of luck for your studies!!!